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(54) Method of Manufacturing Objects of Cured Resin Reinforced with Glass Fibre

(57) A method of manufacturing an object of cured resin reinforced with glass fibre, comprises manufacturing a chopped glass fibre preform 18 having substantially the same shape as the object of supplying chopped glass fibre 12 to a jet 1 of finely divided liquid, for example water, containing a temporary binder for the glass fibre and directing the jet with its contents of glass fibre and temporary binder towards different parts of the surface of a former 14 until a preform with the required amount of glass fibre has built up on the surface of the former. The bonded preform thus produced is placed in a closable forming cavity of a mould (not shown) for moulding the object, and then resin in uncured condition is injected, sucked or pressed into the forming cavity and thereafter cured.

The temporary binder, for example polyvinyl acetate, an alkyd resin, an epoxy resin, a styrene resin or an urethane resin, may be soluble in the uncured resin e.g. a polyester, epoxy or polyurethane used, the temporary binder being maintained in soluble condition when the preform is placed in the forming cavity and the uncured resin is supplied to the mould. The former 14 may be a metallic or PVC mesh, a perforated sheet or a glass fibre fabric impregnated with iron.

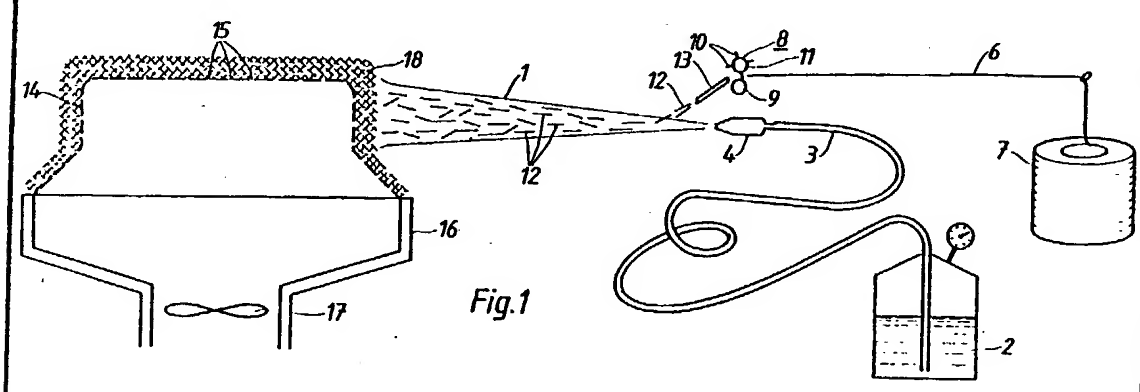

Fig.1

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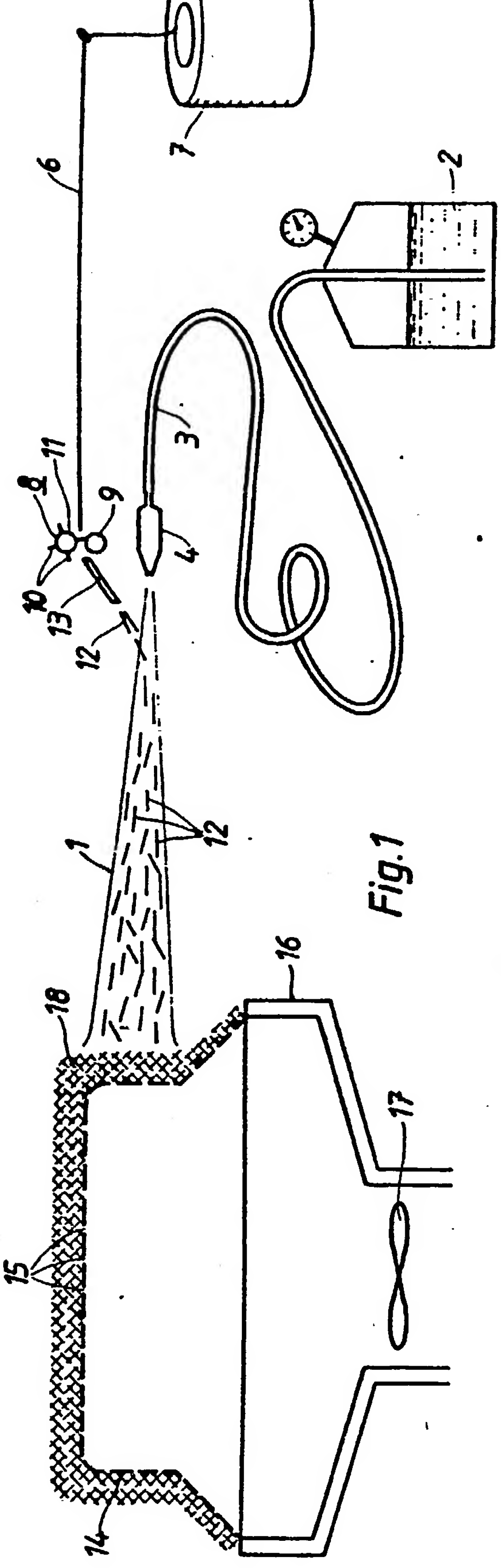


Fig.1

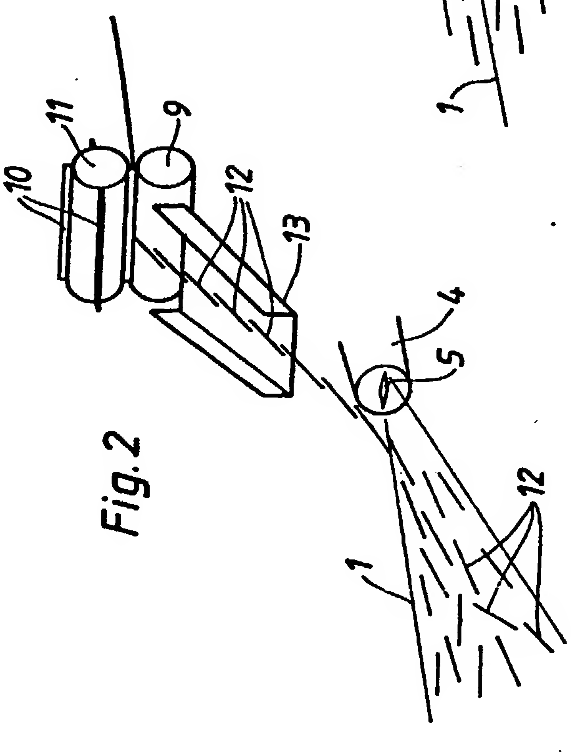


Fig.2

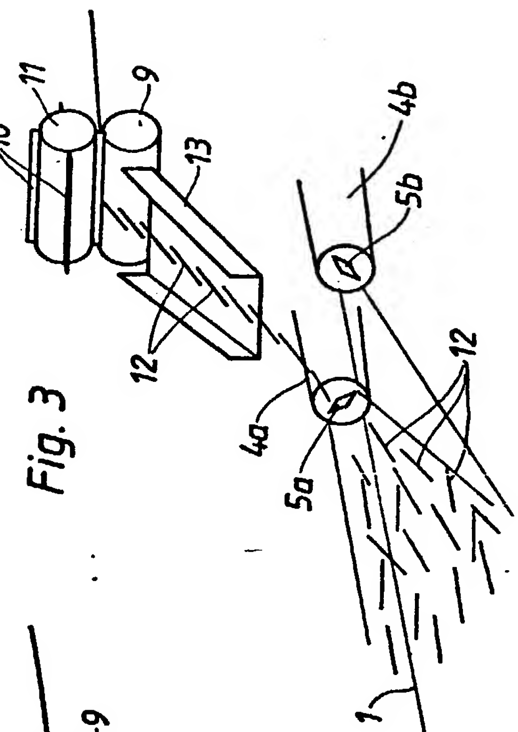
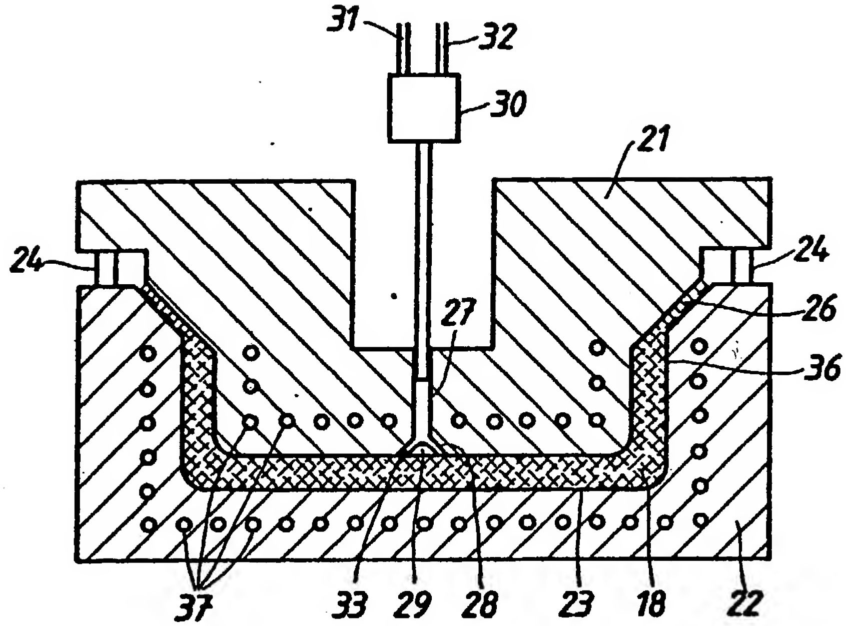


Fig.3

Fig. 4



SPECIFICATION

Method of Manufacturing Objects of Cured Resin Reinforced with Glass Fibre

In the manufacture of large objects of glass fibre reinforced thermosetting resin, for example boat hulls, and in the manufacture of objects in relatively short series, spraying is a much used method. When spraying, the resin and chopped glass fibre are placed on the forming surface used with the help of a spray unit which, by means of pumps or a pressure vessel, feeds the resin, preferably unsaturated ester resin, to one or more nozzles of a spray gun and from this nozzle or these nozzles the resin is sprayed against the forming surface as a liquid screen. In this liquid screen bundles of chopped glass fibre are spread from a small cutter mounted on the spray gun. On their way towards the forming surface, the glass fibre bundles are wetted by the resin and form on the resin a mat of fibres and resin which is then compressed and impregnated into a laminate layer by means of hand tools. Because the resin is provided with a curing agent and possibly an accelerator, it may be cured at room temperature or at an elevated temperature when the spraying has been finished. Several spray units and hand tools are available on the market for the application of this technique, as well as several different resins and different types of glass fibre.

A disadvantage of the method is that it causes environmental problems, due to the fact that the material is applied to a single mould and that the exposed surface, which is often large, enables monomers included in the resin, normally styrene, to become partially evaporated. A good ventilation is therefore necessary. Another disadvantage with the method is that it is work intensive and therefore expensive.

The problems caused by open single moulds can be avoided by manufacturing objects of reinforced thermosetting resin in moulds which consist of mould parts capable of being sealed so that a closed forming cavity is formed. The glass fibre material is then placed in dry condition in the closable mould. When injecting the resin into the mould, or sucking it in under vacuum, the resin is supplied after the cavity with the glass fibre material applied therein has been sealed. When it is a case of manufacturing pressed objects, the resin is poured onto the glass fibre material previously placed in the lower mould part of the mould, and then the upper mould part is pressed down against the lower mould part to provide a closed forming cavity, in which the resin impregnates the glass fibre material. The glass fibre material may, among other things, consist of a preform of chopped glass fibre. The glass fibre is then preformed into the shape the reinforcement will adopt when filling the cavity, and is held together by a binder so that the preform may be applied in the cavity.

The shaping of the preform is usually effected using a preforming screen, usually of perforated sheet, which has largely the same design as the finished reinforced resin object. This preform screen is placed over the suction opening of a powerful centrifugal fan, so that the fan applies a considerable suction to the holes in the preforming screen. The glass fibre roving is chopped into bundles by a cutter and is either allowed to fall down against the preforming screen or is blown towards the screen. Because of the strong suction effected generated below the screen by the fan, the chopped fibre is sucked towards the screen and forms a mat. To obtain as uniform a distribution of the fibre as possible, a high degree of suction must be applied to the preforming screen. A binder is introduced while the glass fibre is being collected on the screen. A polyester powder or emulsion, provided with a curing agent, is normally used as binder. Solutions of polyester in, for example, ethylene acetate, spirit or acetone, are also used in practice. After the glass fibre and binder have accumulated on the preforming screen, the screen is dried and the binder is normally cured. The screen is then placed in a heating zone or a furnace, with the fan still operative to suck the glass fibre and binder against the surface of the screen. It is important for the glass fibre bundles to be strongly bonded to each other so that they do not accompany the resin when it flows into the mould in connection with the moulding of the reinforced object, thus giving rise to an uneven distribution of the glass fibres in the finished object. Preforming of the glass fibre material is common in the manufacture of small-sized and medium-sized objects by hot pressing. The process time is then short.

The preforming process requires a large capital investment, especially because of the powerful fans required, and the operating costs are high. The method is not suitable for the manufacture of large objects because of the great fan capacity that would be required to produce the preforms. Since it is the fan that conducts the glass fibre to the different parts of the preforming screen, there are considerable problems in obtaining the same amount of glass fibre in, for example, corners and edges as on less curved surfaces. It is also difficult to provide preforms with intentionally different thicknesses of the glass fibre layer in different regions.

The present invention relates to a method of manufacturing an object of glass-fibre reinforced resin using a preforming method which requires simple equipment and which permits practically unlimited possibilities of conducting the glass fibre to desired regions of the preform, so that all parts of the glass fibre layer, independently of the shape and size of the preform, can be given the desired thickness.

According to the invention, a method of manufacturing an object of cured resin reinforced with glass fibre, comprises manufacturing a chopped glass fibre preform having substantially the same shape as the object by supplying chopped glass fibre to a jet of finely-divided liquid containing a binder for the glass fibre and

directing the jet with its contents of glass fibre and binder towards different parts of the surface of a former until a preform with the required amount of glass fibre has built up on the surface of the former placing the bonded preform thus produced in a closable forming cavity of a mould for moulding the object, supplying resin in uncured condition to the forming cavity and thereafter causing the resin to cure.

The method according to the invention is particularly suited for use in the manufacture of reinforced objects in which the resin is injected or sucked by vacuum into the closed forming cavity or is supplied to the preform prior to the forming cavity being closed, in the latter case followed by a pressing, and particularly in such cases where the moulding of objects takes place under low pressure and at a low temperature, such as room temperature or a moderately raised temperature.

The preform may be manufactured using used conventional spraying equipment of the type employed for spraying plastics and glass fibre. Because the glass fibre bundles are transported to the former by the finely divided liquid jet and the jet can be directed towards an arbitrary part of the former, a desired thickness of the glass fibre layer can be achieved at each part of the preform.

The former can suitably be made of a foraminous material, for example a metallic or plastics mesh material, for example PVC, or perforated sheet. A particularly advantageous design of former is provided by an open glass fibre fabric which has been impregnated with resin and, after allowing surplus resin to run off, has been placed in a mould and allowed to cure. A former of this kind is pervious to gas and liquid.

In certain applications of the method of the invention it may be suitable to place the former over a suction fan to accelerate the evaporation of the liquid and to retain the sprayed-on fibre on vertical surfaces of the former. For these purposes, however, a considerably lower fan capacity is required than in conventional preforming in which the entire fibre distribution is controlled by the fan.

From the environmental point of view and to reduce the fire hazard, water is preferred as the liquid in the jet. However, it is possible to use other solvent liquids, for example ethanol and methanol.

It has been found advantageous that the liquid supplied by the jet should have a low viscosity to provide a good binding effect and a low dry content so that too large a binder content is not left in the finished preform after drying. The viscosity of the liquid is preferably from 1 to 10 centipoise at room temperature and the dry content preferably from 5 to 20 *per cent* by weight. The binder content in the finished preform, that is when the liquid has evaporated, is preferably 3 to 15 *per cent* of the total weight of the binder and glass fibre in the preform.

In a particularly preferred embodiment of the method there is used a binder which is soluble in the uncured resin and the binder is maintained in soluble condition when the preform is placed in the forming cavity and the resin in uncured state is supplied. Preferably, the solubility of the binder in the resin is such that the binder holds the glass fibre in position in the preform when the resin, in uncured condition, is supplied to the forming cavity and is distributed in the glass fibre and that the binder at least in all essentials is dissolved in the resin when the curing of the resin starts. Because the binder holds the glass fibre in position until it has been distributed in the preform, the formation of portions having a low glass fibre content and the formation of wrinkles in the object are avoided. Because the binder is dissolved in the resin when the curing starts, there is avoided the danger of a film of binder on the glass fibre preventing direct contact between resin and glass fibre with consequent deterioration of the mechanical properties of the object.

As examples of suitable binders may be mentioned polyvinyl acetate, alkyd resins, epoxy resins, styrene resins and urethane resins. The exemplified binders are soluble, emulsifiable or suspendable in water.

It has proved advantageous in certain cases to use a mixture of at least two binders having different solubility, one having a short solubility time and one having a longer solubility time in the resin used. By varying the proportions of the binders, it is possible to influence the solubility time for the mixture and thus adapt it to the shape and thickness of the preform used.

The resin is preferably in the form of an unsaturated ester resin of any of the types conventionally used in the manufacture of glass-fibre reinforced resin. Its unsaturated monomers are preferably styrene, methyl methacrylate or vinyl toluene. The resin may also consist of other solvent-free resins such as epoxy resins and urethane resins.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which

Figure 1 is a schematic view of a device for manufacturing a preform for use in the method according to the present invention,

Figures 2 and 3 show details of Figure 1 on an enlarged scale, and

Figure 4 is a schematic sectional view of a device for manufacturing a reinforced object employing the preform made with the device of Figure 1.

In Figure 1, a finely-divided jet 1 of water containing a binder is generated in a spray unit which comprises a pump or pressure vessel 2 connected by a conduit 3 to a spray gun 4. The conduit 3 is flexible so that the spray gun can be moved and turned in arbitrary directions. The spray gun nozzle is provided with a slot 5 (Figure 2) and 5*a* and 5*b* (Figure 3), respectively, which influences the shape of the jet. As shown in Figure 2 a single spray gun 4 may be used having in its nozzle a single elongate slot 5 which provides an essentially plane jet 1. Alternatively, as shown in

Figure 3, two spray guns 4*a* and 4*b* are used having nozzles with elongate slots 5*a* and 5*b*, respectively, disposed at an oblique angle to each other. In this case a jet 1 having a V-shaped cross-section is formed. The jet consists of water containing 8 *per cent* by weight of polyvinyl acetate.

Glass fibre in the form of roving 6 having a count of 2400 Tex (g per km) and a diameter of 10 microns in the individual glass fibres is fed from a package 7 to a cutting tool 8. The cutting tool consists of a smooth rubber roll 9 cooperating with a metallic roll 11 provided with knives 10. This cutting tool cuts the roving into bundles 12 having a length of about 3 cm, which bundles are allowed to fall down into the jet 1 via an inclined chute 13. The jet then transports the glass fibre to a foraminous former 14, which is pervious to gas and liquid. The former is made of a glass fibre fabric which has been impregnated with an unsaturated ester resin and cured, after surplus resin has run off leaving openings 15 at the meshes. The former 14 is placed on a funnel-like table 16, in which there is arranged a low capacity fan 17 to facilitate the discharge of water from the layer of glass fibre built up on the former 14 and to assist in retaining fibre sprayed up on the vertical surfaces of the former. When the former 14 has been provided on all outwardly facing surfaces with a fibre layer of the desired thickness, the process is interrupted and the preform 18 is dried to remove the water.

The preform is then placed in a mould in which the end object is to be manufactured. One example of such manufacture, employing injection moulding of the resin, is illustrated in Figure 4.

The mould shown in Figure 4 has two mould parts 21 and 22, which form between themselves a forming cavity 23 and which are held in a fixed position in relation to each other by spacers 24. The mould parts are held pressed against each other by a clamping device (not shown). The mould may be manufactured of, for example, glass-fibre reinforced plastics material, aluminium or steel. Before bringing together the mould parts 21 and 22, the previously described preform 18 has been placed in the forming cavity 23. The edges of the preform project into the compression gap 26 and are clamped there between the mould parts 21 and 22. The thickness of the gap 26 is adjusted so that it allows air to escape from the forming cavity but does not allow, or only allows to a minor extent, the passage of resin in uncured condition. The upper mould part is provided with an inlet 27 for uncured resin. The portion of the inlet located nearest to the forming cavity 23 is formed as a valve, consisting of a valve seat 28 and a loose valve body 29 of polypropylene. The resin, which in the exemplified case consists of an unsaturated ester resin with styrene as monomer (e.g. "Crystic" 2230 from AB Syntes, Sweden) is introduced by an injection gun 30. The styrene content of the ester resin amounts to 35 *per cent* of the weight of ester resin including the styrene.

The resin is mixed in the gun so immediately before being injected by mixing resin containing catalysts, for example 1 *per cent* by weight of benzoyl peroxide, from a conduit 31 with resin of the same kind containing an accelerator, for example 0.05 *per cent* by weight of dimethyl paratoluidine, from a conduit 32. When the resin has been injected it fills up the forming cavity and is distributed in the preform 18 while at the same time air is forced out through the gap 26. As soon as the resin has reached the gap 26, which may take only one or a few minutes when using a low-viscosity resin, the supply of resin is interrupted by closing the gun 30. During this process, the binder efficiently retains the glass-fibre bundles in position in the preform. During the injection, the valve body is pushed downwards by the resin so that a gap 33 is maintained between the valve seat 28 and the valve body 29. When the injection is interrupted, the valve body is automatically pushed upwards because of the back pressure from the resin in the forming cavity 23, thus sealing the inlet. When the resin starts to cure after about 10 minutes, all binder is dissolved. After about 30 minutes the curing is finished. The finished object is then removed from the mould and the edges are cut off at 36. The mould parts may contain built-in tubular coils 37 which may be used for cooling if the mould becomes too hot because of an exothermic curing reaction in the resin, or for a certain preheating of the mould before the exothermic reaction maintains it at the desired temperature, for example somewhat above room temperature.

Claims

1. A method of manufacturing an object of cured resin reinforced with glass fibre, comprising manufacturing a chopped glass fibre preform having substantially the same shape as the object by supplying chopped glass fibre to a jet of finely-divided liquid containing a binder for the glass fibre, and directing the jet with its contents of glass fibre and binder towards different parts of the surface of a former until a preform with the required amount of glass fibre has built up on the surface of the former, placing the bonded preform thus produced in a closable forming cavity of a mould for moulding the object, supplying resin in uncured condition to the forming cavity and thereafter causing the resin to cure.

2. A method according to claim 1, in which a binder which is soluble in the uncured resin is used, the binder being maintained in soluble condition when the preform is placed in the forming cavity and the uncured resin is supplied to the mould.

3. A method according to claim 1 or 2, in which the liquid used consists of water.

4. A method according to claim 2 or claim 3 when dependent on claim 2, in which the solubility of the binder in the uncured resin is such that the binder maintains the glass fibre in position in the preform when the resin in uncured condition is supplied to the forming cavity and

distributed in the preform, the binder, at least in all essentials, being dissolved in the resin when the curing of the resin starts.

5. A method according to any of the preceding claims, in which the binder comprises or consists of polyvinyl acetate.

6. A method according to any of the preceding claims, in which the former used is made of glass fibre fabric impregnated with resin and the form after curing of the resin is pervious to gas and liquid.

7. A method of manufacturing an object of cured resin reinforced with glass fibre, substantially as herein described with reference to the accompanying drawings.

8. An object of cured resin reinforced with glass fibre when made by the method claimed in any of the preceding claims.

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